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The Rhode Island Benchmarks

Scope and Sequence

Suggestions for a comprehensive scope and sequence are currently under development by Project 2061.

Science Process Skills

"The single most important factor influencing learning is what the learner already knows."

D. P. Ausubel, Educational Psychology: A Cognitive View. NY: Holt, Rinehart, and Winston. 1968, p. i)

Science process skills have been a routine part of nearly every curriculum document in science education for many decades. The science framework addresses these skills in a way that we hope will make them more meaningful to classroom teachers and curriculum developers. Instead of laundry lists of skills associated with each activity, we have keyed all activities to just a few skills that lie within particular arenas. As Figure 1 suggests, we believe that basically four arenas interact in determining the kinds of skills used in a science learning experience and the quality of the skills utilized. The core arena is foundational habits of mind and affect. These foundational habits are described in some detail in Chapter 12 of the *Benchmarks for Science Literacy* and in *Science For All Americans* of Project 2061. Briefly, one can think of them as general orientations toward knowledge, persons, and things that learners have resident with them before entering the science classroom. These are essentially attitudes and dispositions that are based on life experiences and philosophical beliefs. They are also habits which are relatively difficult to change or substantially alter. Yet they influence all subsequent learning experiences and human interactions - including what happens in science learning.

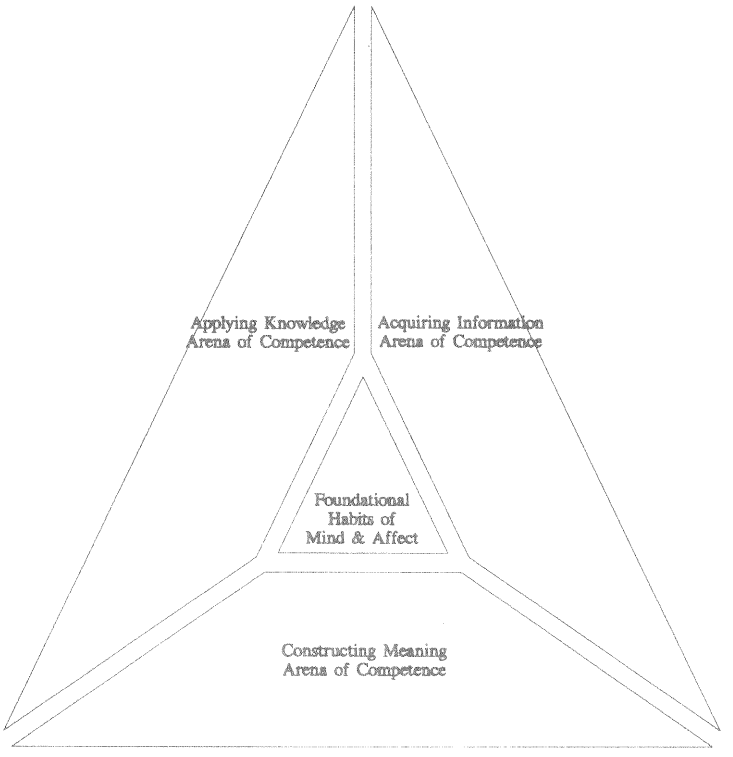

Figure 1.

Three other arenas interact with the foundational habits which the learner brings to the learning task: acquiring knowledge, constructing meaning, and applying knowledge. These arenas are all highly interactive with one another and decidely not linear in nature. Learning consists largely of making meaning out of a wide array of objects, phenomena, and processes in the world around us. In this sense, the construction of meaning is the central focus of the learning enterprise. This meaning is constructed personally by the learner and may or may not involve a substantial social process of knowledge construction with others (such as in varied forms of cooperative learning and informal social interaction). But even this construction of meaning is mediated by the knowledge/information that learners already possess, the new information that they acquire, and their experiences in applying their knowledge to new situations. In fact, the truest test of the worth of personal knowledge is application - does the learner find new uses for the knowledge so as to validate its meaning and functionality.

Within each arena of competency there are various proficiencies which might be identified. Figure 2 presents a few of the major proficiencies one might consider as lying under each arena. For example, in the Acquiring Information Arena, we can identify four major proficiency domains which learners must exercise if their search for new information is to achieve success: experimental, mathematical, language, and

If we expand upon these concepts to a more full-blown taxonomy of process skills, we end up with a diagram similar to Figure 3. The foundational habits undergird and strongly interact with all other dimensions of the process skills. Under each proficiency we may identify a variety of skills which one might use/demonstrate as one engages in acquiring information, constructing meaning, or applying knowledge. The taxonomy is not intended to be exhaustive but illustrative of the various kinds of skills that successful science learners will exhibit. Even young children exhibit many of these proficiencies at the start of their formal schooling. Part of the process of formal education is to increase the breadth and depth of these skills as part of the affective, cognitive, and psychomotor 'toolkits' that learners possess. High quality success at these skills equips learners not only for high achievement in school but success in life.

This taxonomy can be used by a teacher to begin to approach science process skills within a broader conceptual framework than the usual laundry lists. Every class has individuals who already exhibit excellence in one or more proficiency domains and deficiencies in other domains. Some learners are very good in individual tasks but very inept when it comes to collaborating with others to achieve common ends. As teachers, we can better identify where students are on these continuums, from poor to excellent, and consciously use this information to create a range of opportunities for all students to increase the breadth and depth of their science process skills. We are interested in hearing from teachers about how useful this taxonomy proves to be and how it might be improved as we move toward a second edition of the RI State Science Framework.

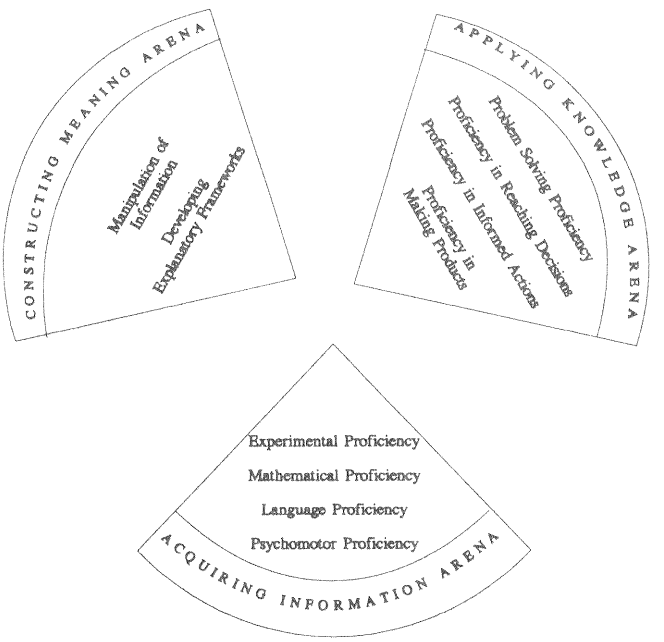

Figure 2

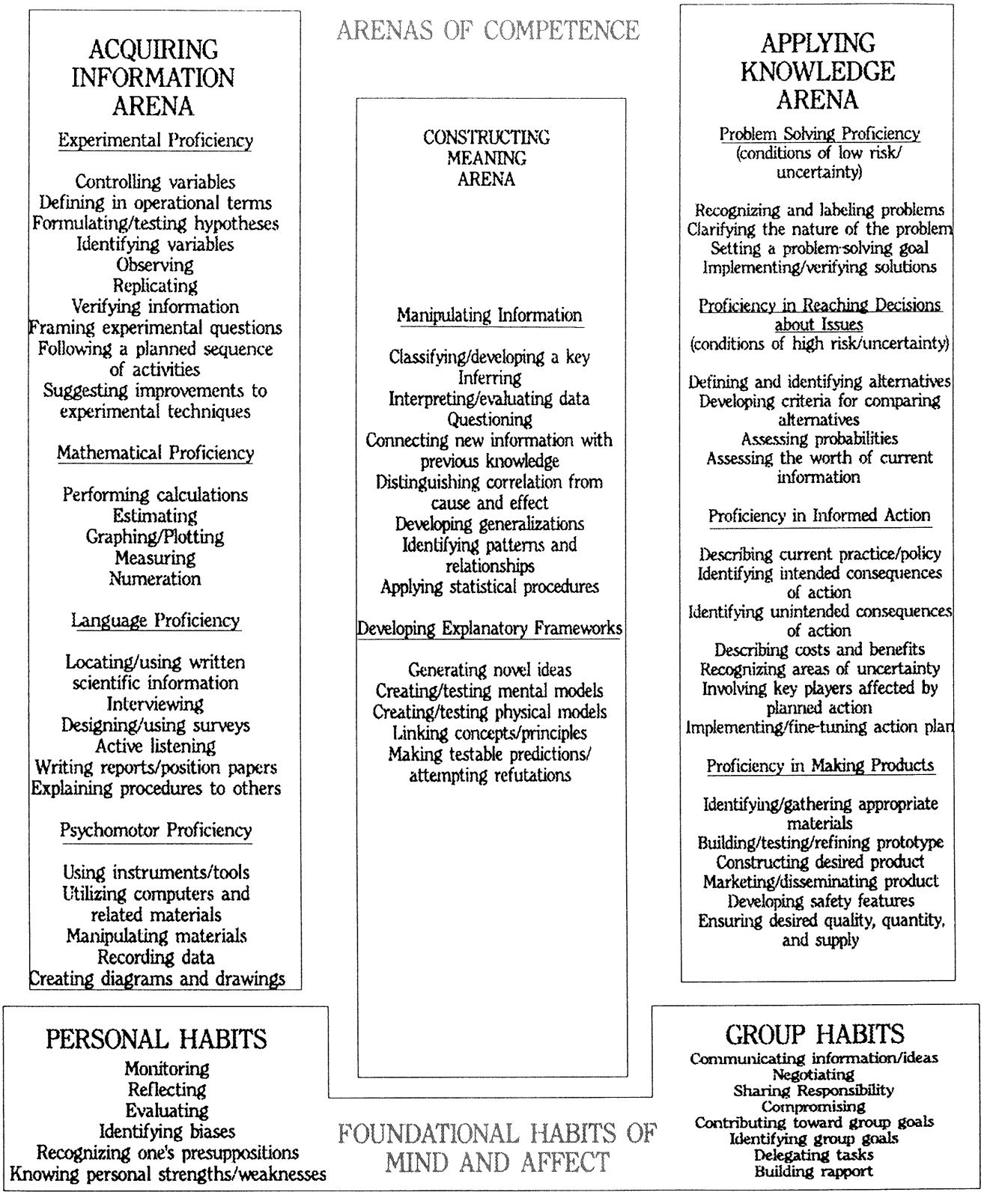
ARENAS OF COMPETENCE
ACQUIRING INFORMATION ARENA
Experimental Proficiency
Controlling variables
Defining in operational terms
Formulating/testing hypotheses
Identifying variables
Observing
Replicating
Verifying information
Framing experimental questions
Following a planned sequence of activities
Suggesting improvements to experimental techniques
Mathematical Proficiency
Performing calculations
Estimating
Graphing/Plotting
Measuring
Numeration
Language Proficiency
Locating/using written scientific information
Interviewing
Designing/using surveys
Active listening
Writing reports/position papers
Explaining procedures to others
Psychomotor Proficiency
Using instruments/tools
Utilizing computers and related materials
Manipulating materials
Recording data
Creating diagrams and drawings
CONSTRUCTING MEANING ARENA
Manipulating Information
Classifying/developing a key
Inferring
Interpreting/evaluating data
Questioning
Connecting new information with previous knowledge
Distinguishing correlation from cause and effect
Developing generalizations
Identifying patterns and relationships
Applying statistical procedures
Developing Explanatory Frameworks
Generating novel ideas
Creating/testing mental models
Creating/testing physical models
Linking concepts/principles
Making testable predictions/ attempting refutations
APPLYING KNOWLEDGE ARENA
Problem Solving Proficiency
(conditions of low risk/ uncertainty)
Recognizing and labeling problems
Clarifying the nature of the problem
Setting a problem-solving goal
Implementing/verifying solutions
Proficiency in Reaching Decisions about Issues
(conditions of high risk/uncertainty)
Defining and identifying alternatives
Developing criteria for comparing alternatives
Assessing probabilities
Assessing the worth of current information
Proficiency in Informed Action
Describing current practice/policy
Identifying intended consequences of action
Identifying unintended consequences of action
Describing costs and benefits
Recognizing areas of uncertainty
Involving key players affected by planned action
Implementing/fine-tuning action plan
Proficiency in Making Products
Identifying/gathering appropriate materials
Building/testing/refining prototype
Constructing desired product
Marketing/disseminating product
Developing safety features
Ensuring desired quality, quantity, and supply
PERSONAL HABITS
Monitoring
Reflecting
Evaluating
Identifying biases
Recognizing one's presuppositions
Knowing personal strengths/weaknesses
FOUNDATIONAL HABITS OF MIND AND AFFECT
GROUP HABITS
Communicating information/ideas
Negotiating
Sharing Responsibility
Compromising
Contributing toward group goals
Identifying group goals
Delegating tasks
Building rapport

Figure 3